Market barriers for harmonised demand-response in balancing reserves: cross-country comparison

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Abstract — **Electricity systems require flexibility to maintain their operations. This can be provided by demand response (DR). Therefore, markets are evolving to be more open to DR. However, there still exist barriers for DR participation. These can be categorised into product, economic, technical and consumer barriers. On the other hand, there is a trend towards harmonising national electricity markets so that international exchange could be possible. As these two trends can counteract each other, problems may arise. The interaction of these two trends is discussed while looking at two forms of reserves across four countries: Belgium, the Netherlands, Germany and France. In this way, different product characteristics can be found. Hence, it is recommended that harmonisation should focus on DR first, with an emphasis on aggregation possibility, before trying to converge other characteristics and potentially strengthen other barriers.**

Index Terms — **demand response, harmonisation, product barriers, reserve market**

I. Introduction

Electricity systems have always needed flexibility to maintain their balance. With the rising amount of renewable, variable energy, this requirement becomes even more important. Flexibility can be provided by several sources such as flexible power plants or electricity storage. Another way of providing this is demand response (DR). With DR, consumers will react to peak demand by curtailing their loaf or by shifting it to periods with lower demand. In this way, no extra generation is required in the peak periods to balance the system [1].

DR can be categorised into two types. First, price-based DR will introduce dynamic pricing in order to let consumers decide when and how they will curtail or shift their demand. Second, incentive-based DR will provide financial incentives for demand shedding independent from the electricity price at that time. This can be done e.g. by a third party without actions from the consumers (direct load control) or by giving the consumers the responsibility of shedding (curtailable load) [1].

With the current transition towards sustainable energy supply, DR is seen as a step of the solution. Therefore, the EU has already incorporated DR in some of their directives, i.e. the Electricity Directive (2009/71/EC) and the Energy Efficiency Directive (2012/27/EU). This last Directive specifically addresses that barriers for DR participation have to be removed and that DR has to be encouraged [2]. At the same time, there is a transition towards a harmonised electricity market. Creating a larger market will not only allow suppliers of reserves to choose from more buyers, but will also improve adequacy as more reserves are available in time of emergency [3]. However, these two trends should not contradict each other by steering the market in opposite directions. This paper will look at what the current status of this problem is, specifically for reserve markets.

Section II discusses the different kind of barriers for demand response. Section III gives an explanation and some examples of the harmonisation of electricity markets. Section IV explains the reserve market for Belgium, The Netherlands, Germany and France. Section V discusses the barriers of these countries for two kinds of reserves. Section VI will conclude this paper.

II. Barriers for demand response

Most of the barriers for participation in DR products can be organised into four categories: product, economic, technical and consumer related barriers [4]. As the focus in this paper lies on the product barriers, these will be discussed more thoroughly while the economic, technological and consumer barriers are briefly explained.

A. *Product barriers*

Originating from the design of the regulatory framework, the market and the product itself, product barriers exist because market structures are still focused on the characteristics of the generators that used to be the only players in the market. With the rise of aggregators, these old market structures can act as a barrier as they protect the incumbent suppliers and may not be suitable for participation of aggregators [4]–[6]. In this way, this could be seen as a barrier imposed by the TSO. There are three important product barriers: minimum size, timing requirements and symmetry.

The first product barrier is the requirement of a minimum bid size [5]–[9]. Traditional suppliers have large, centralized generation units which easily have an output in the range of hundreds of MW. However, for distributed suppliers and DR products in general, this is out of range: the lower the threshold, the better for them. A solution for this is to aggregate several installations to make it easier to meet the threshold [6].

The second product barrier is related to the time requirements [4]–[7]. These include duration of the product, minimum run times and minimum down times. For DR products, generally speaking, it is better to have short run times and enough time between activations in order to not totally disrupt the consumers' activities but this depends on the installation.

The last product barrier is the symmetry of the bids [5], [6], [10]. For DR products, it is more difficult to provide downwards (load increasing) than upwards (load shedding) capacity than for traditional generators [6]. When perfect symmetry of bids is required, DR products will have to aggregate with other products to comply with this requirement.

B. *Economic barriers*

Economic barriers exist when there are financial (dis)incentives which hamper the usage of DR products [4]. These are mainly present when the financial incentives are too low or not existing at all. A prime example is that price differences between periods are not high enough to make households or businesses react to it [4]. Furthermore, consumers may choose not to participate in DR programs as they may increase their bills due to high peak demand usage. Another example is that penalties may be set too high for DR programmes to take the risk of non-compliance and having to pay the penalty [7].

C. *Technical barriers*

These barriers are related to special requirements for the system or consumers in order to support DR [4]. An important barrier is that the required technology is not present at the consumer site: e.g. it is not possible to have time-varying prices if there is no meter present with those functionalities [6], [8], [11], [12]. Furthermore, these barriers are also present in the system itself: network and scheduling constraints can exist when demand is shifted if the grid is not suitable to handle these flows [13]–[16].

D. *Consumer barriers*

The last set of barriers are related to consumers and the corresponding retail market. An example of a more "soft" barrier related to consumer behaviour is that consumers may not be aware that they can participate in DR programmes or that they may not trust the system, which can lead to a inelastic demand [8]. This inelastic demand on its own can also be a barrier as consumers may not be willing to react to dynamic pricing or financial incentives.

But the retail markets themselves also suffer from barriers. An example are policy restrictions that hamper the usage of DR in the retail market, which is mostly the result of not having the freedom to design rates. A related barrier is that the prices in wholesale markets are more variable than in the retail market with (mainly) fixed prices. As long as consumers are not or cannot be rewarded, DR will have difficulties breaking through. However, it is important to note that the opposite is also true: as long as DR is not present for end-consumers, the required technology will not be necessary and thus investments will stall [4].

III. Harmonisation of Electricity markets

A move towards DR is not the only trend in electricity systems. Starting in 2009, the European Commission launched harmonising rules in order to create a European wide electricity market (i.e. market coupling) [3]. These are part of the Third Energy Package where the EU imposes legislation to improve the efficiency of the energy market [17]. Following these introductions, the European Network of Transmission System Operators for Electricity (ENTSO-E) was established, with the task to implement several objectives for harmonisation [18], [19].

The focus of this market coupling was mainly on electricity trading markets [20]. But even a fully harmonised electricity trading market is not enough to ensure an efficient system as ancillary services will also be required [3]. A fully harmonised EU balancing market is not yet active due to the lack of regulation and cooperation between national system operators, although this is on the agenda of the regulators [21], [22]. Currently, only regional projects are present such as the Nordic balancing market in Sweden, Finland and Norway which will be launched in 2016 [3], [23].

There are several reasons why a harmonised balancing market is important. First, TSOs will benefit from a more harmonised and thus larger market as this increases the number of suppliers of reserves. This will reduce market power from the incumbent suppliers and increase competition [20], [21]. This is an important reason as there currently exists a high market concentration for balancing markets. Second, a larger harmonised market will improve operational security as risks are spread over a larger number of balancing possibilities [21].

IV. Reserve markets

In this section, the reserve markets of four neighbouring countries in continental Europe will be described. The focus is on the Frequency Containment Reserves (FCR) and automatic Frequency Restoration Reserves (aFRR). The manual FRR and Restoration Reserves are outside the scope of this paper as the differences between the considered countries for these reserves are rather large [18]. Other reasons for this scope are that the FCR products are considered better to harmonise than other reserves and that the activated aFRR represents a large part of the reserves without FCR in these countries [24]. However, it can be interesting to consider these products in a further study to investigate why these differences are present. The information about the characteristics described here can be found on the websites of the respective TSOs.

A. FCR

The FCR products are the first reserve type to counter frequency deviations. These products should be able to stabilise the frequency drop or increase almost immediately so that aFRR products can be activated to restore the frequency [25].

As these products are important to counter the first deviations, the specifications are described and coordinated by ENTSO-E. The result is that the characteristics of these products differ minimally between different countries (of the same synchronous area). A few characteristics are already aligned: aggregation is allowed, the activation time is a few seconds, the maximum time for 50% and the full activation time (FAT) is 15 s to 30 s, respectively, and the minimum size is 1 MW with increments of 1 MW, except for Belgium where this is only 0.1 MW.

1) Belgium

Currently, Belgium is required to contract 73 MW of FRR ("Primaire reserve") in 2016. This is split up into four products: two symmetrical products and two asymmetrical ones, both for upwards and downwards changes. DR products are only allowed to participate in the asymmetric upwards product today, due to the nature of DR.

These products are auctioned on monthly basis on an organised market, with the pay-as-bid price as their price. This price covers both the activation and stand-by costs.

2) The Netherlands and Germany

For the Netherlands the amount of required FCR ("Primaire regeling") was 101 MW in 2016. There is only one product present, which is symmetrical, and load is not allowed to participate on the internal market. Important to note is that since January 2014, a part of the contracted FCR is procured on the German-Swiss system as a first step to harmonisation. In order to simplify this cooperation, the Dutch TSO decided to take the same characteristics for the products and tenders, which is why these two countries are considered together here. Germany on its own procures 583 MW "Primärregelleistung" on the common auction.

Like the case for Belgium, there is an organised market for the bids, with pay-as-bid as the payment. The difference is that auctions take place weekly.

3) France

France needs a FCR ("Réglage primaire de fréquence") of 572 MW [26]. This is also symmetrical but the market is not completely open. Instead, each generator is required to provide capacity at a regulated price of €18 per MW per hour. Recently, the market opened up via bilateral agreements for DR participation (in 2014) and for traders (in 2015).

B. aFRR

There are two forms of FRR products which differentiate on the mode of activation: automatic (aFRR) or manual (mFRR). The aFRR products are activated first. If the frequency deviations are still not restored, the TSO will send out activation requests to the contracted suppliers who will manually activate their mFRR. In this way, the aFRR is freed so that it can be used for future imbalance situations [25].

Compared to the FCR products, TSOs are more free to determine the characteristics of the FRR products. Therefore, the products will be more differentiated and less harmonised.

1) Belgium

The aFRR for Belgium ("Secundaire reserves") are split between upwards and downwards products. The same amount is contracted for both products so that there exists one symmetrical aggregated product. This means that it should be easier for DR products to participate in this market but they are not allowed to due to current legislation.

As for FCR, the minimum size is 1 MW, with increments of 0.1 MW and the bids are auctioned on a monthly basis with a pay-as-bid price. For the activation, bids are ranked from lowest price to highest price and are selected in ascending order until the required amount is reached. Then, the bids are activated pro rata so that every contracted supplier contributes the same share. The reaction time is maximum 30 s with a FAT of 7.5 min as the ramp rate has to be 13.3% per min.

2) The Netherlands

"Regelvermogen" is the Dutch aFRR and this exists in both upwards and downwards products. Load products are allowed but aggregation is not which may make it difficult for DR to participate in reality. On the other hand, symmetry is not necessary.

The minimum size is 4 MW with increments of 1 MW. These products are auctioned on a yearly basis but instead of a merit-order approach, the Dutch TSO tries to get the lowest average price for the aFRR reserves in total. Because prices are linked to certain volumes, selecting only the cheapest bids may not result in the lowest total price. The activation of the bids happens according to a merit-order. With a ramp rate of 7% per min, there is a FAT of 15 min which is among the largest in Europe. The reaction time is maximum 30 s.

3) Germany

The "Sekundärregelleistung" also has both upwards and downwards products as symmetry is not required. Furthermore, both DR and aggregation are allowed to participate.

The minimum size is 5 MW with increments of 1 MW. The auctions happen on a weekly basis with pay-as-bid as the price. In contrast with the other countries, this price is for both the capacity (provision) and the energy (activation). The selection is based on the balancing capacity with the merit-order principle, which is also used to determine which bid to activate. The reaction time is also 30 s with a FAT of 5 min but in contrast with the other countries, there is no fixed ramp rate.

4) France

"Réglage secondaire de fréquence" is open for DR products but has a requirement for symmetry, contrary to the aFRR products of the other countries. However, aggregation is allowed so upwards load products can be aggregated with downwards generation to provide symmetric products.

The minimum bid size is 1 MW. Generators are obliged to provide a certain amount of aFRR at a price of €18 per MW per hour. The selection is made on a pro-rata basis. The reaction time is a few minutes with a FAT from 6 to 9 min.

V. Country comparison & Recommendations

A. FCR

In **Table I**, the different characteristics for FCR in the discussed countries are presented. The table is divided in three columns according to three categories of barriers: DR, harmonisation of reserves or shared between them. Where characteristics are already partly harmonised and positive for the implementation of DR, these are coloured grey.

There is not much difference for the specific DR barriers: only the Netherlands do not allow load products to participate.

For the shared barriers, there are two main differences. The first one is the requirement for symmetrical bids. DR, as well as some generators, has difficulties to provide symmetric products due to the nature of the product. Of the discussed countries, only Belgium currently allows asymmetric products to participate. However, they all allow aggregation which alleviates the symmetry requirements. The second one is the frequency of the tenders. This ranges from daily to monthly. The longer the timeframe of the tenders, the more difficult it is for consumers or aggregators to take part as it requires detailed information to plan DR over a long time [5].

The barriers for the harmonisation of reserves focusses on the structure of the auctions. Except for France, the other countries have an organised market where FCR is exchanged, with a pay-as-bid price. However, in France, generators are obliged to participate and receive a regulated, fixed price for this. Although DR is allowed to participate as FCR, this is only via bilateral contracts and not via a market.

In total, differences for FCR products seem low, except for tendering, because of the focus on harmonisation for his product by the Network Codes of ENTSO-E [27]. However, further harmonisation should still take into account the differences in order to have a level playing field for DR to participate (e.g. by changing to a daily frequency of tenders).

Table I FCR Characteristics

	Demand barriers		Shared barriers between demand and harmonisation						Harmonisation barriers	
Country	Load access	Aggregation	Symmetry required	Reaction time (s)	FAT (s)	Min. bid size (MW)	Increment (MW)	Tender frequency	Capacity procurement	Capacity payment
BE	Y	Y	N	15	30	1	0.1	Monthly	Organised market	Pay-as-bid
NL	N	Y	Y	15	30	1	1	Weekly	Organised market	Pay-as-bid
DE	Y	Y	Y	15	30	1	1	Weekly	Organised market	Pay-as-bid
FR	Y	Y	Y	15	30	1	/	Daily	Mandatory provision	Regulated price

B. aFRR

In Table II, the different characteristics for aFRR are presented. As for the table for FCR, the table is split into demand barriers, shared barriers and harmonisation barriers. Looking at the table, we see that differences are more frequent than for FCR. This is not completely a surprise as ENTSO-E allows more freedom for the countries to decide on the required characteristics. This is because continental Europe is divided into several Load-Frequency Control Blocks which often are countries (e.g. Belgium is one Block) and which all have a controller to determine whether aFRR has to be activated or not [28]. Therefore, national interests can influence the decisions on how to set the characteristics.

This difference is also clear when the DR barriers are compared. Germany and France are both open for DR and aggregation, while the Netherlands does not allow aggregation and Belgium does not allow DR at all. This can be a result of the obligation in Belgium that all reserves for the TSO (except R1) need a meter behind the meter to ensure correct measurement [5].

Looking at the shared barriers, there are again more differences present than for FCR and these are spread over all the countries. The most obvious differences are symmetry requirements, FAT, ramp rates and minimum bid size. This can cause a serious problem when these countries form a market for aFRR together as not all reserves will be able to participate in all countries. The frequency of the tenders also is a barrier for harmonisation, as most countries have a different timeframe.

For the harmonisation barriers, the pricing rules are roughly the same for each country except for France as it has a regulated price. However, the procurement and activation rules are quite different. In Belgium and the Netherlands, capacity is procured according to a co-optimisation with FCR (Belgium) or optimising to the lowest average total price (the Netherlands). In Germany however, the bids include both a capacity and energy price so that they are procured together. Another difference are the activation rules of the reserves. While in Belgium and France this is done pro-rata, as is the case for almost all of Europe [28], Germany and the Netherlands use a merit order approach. The problem here is that should there be a cross-border exchange of these reserves, it is not as efficient as it would be when all countries would have a merit order approach [29].

It is clear that differences for aFRR products are larger than for FCR: there is not one characteristic that is harmonised over the four discussed countries. This poses a challenge when further harmonisation is discussed. If the focus is solely on harmonisation, the possibility exists that this increases barriers for DR. For example, if all countries converge to the French approach, aggregation would be allowed which eliminates one barrier for DR but at the same time, symmetry will be required which increases the barriers, although this could be party compensated by the new aggregation possibility.

Table II aFRR characteristics

	Demand barriers		Shared barriers between demand and harmonisation							Harmonisation barriers		
Country	Load access	Aggregation	Symmetry required	Reaction time (s)	Ramp rate	FAT (min)	Min. bid size (MW)	Increment (MW)	Tender frequency	Capacity procurement	Capacity payment	Activation rules
BE	N	N	N	30	13.3% per min	7.5	1	0.1	Monthly	Co-optimising with FCR	Pay-as-bid	Pro-rata
NL	Y	N	N	30	7% per min	15	4	1	Annual	Lowest average total price	Pay-as-bid	Merit order
DE	Y	Y	N	30	None	5	5	1	Weekly	Together with energy	Pay-as-bid	Merit order
FR	Y	Y	Y	Few minutes	/	6-9	1	/	/	Mandatory	Regulated price	Pro-rata

VI. CONCLUSION

The research in this paper discussed how DR barriers are currently present in the reserve markets and how harmonisation impacts this. For FCR products, previous harmonisation led the way to products that are open for DR. However, for aFRR, this picture is not that clear. As harmonisation can still go both ways for this reserve, it is important to take into account the barriers for demand response when deciding on the characteristics of a harmonised market. Important differences are the symmetry requirements and the minimum bid size as these represent characteristics that are difficult for DR to comply with. However, as aggregation can alleviate these problems, this is the most important characteristic to consider.

Taking into account the recommendations of this paper, harmonisation can be directed into a more DR-friendly approach. This will improve flexibility of our power system and thus provide a foundation for the further increase of renewable energy sources.

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